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Modelling the Economic Resilience Effects of Climate Adaptation Infrastructure Investments in Senegal: Evidence from a Dynamic Stochastic General Equilibrium (DSGE) Model

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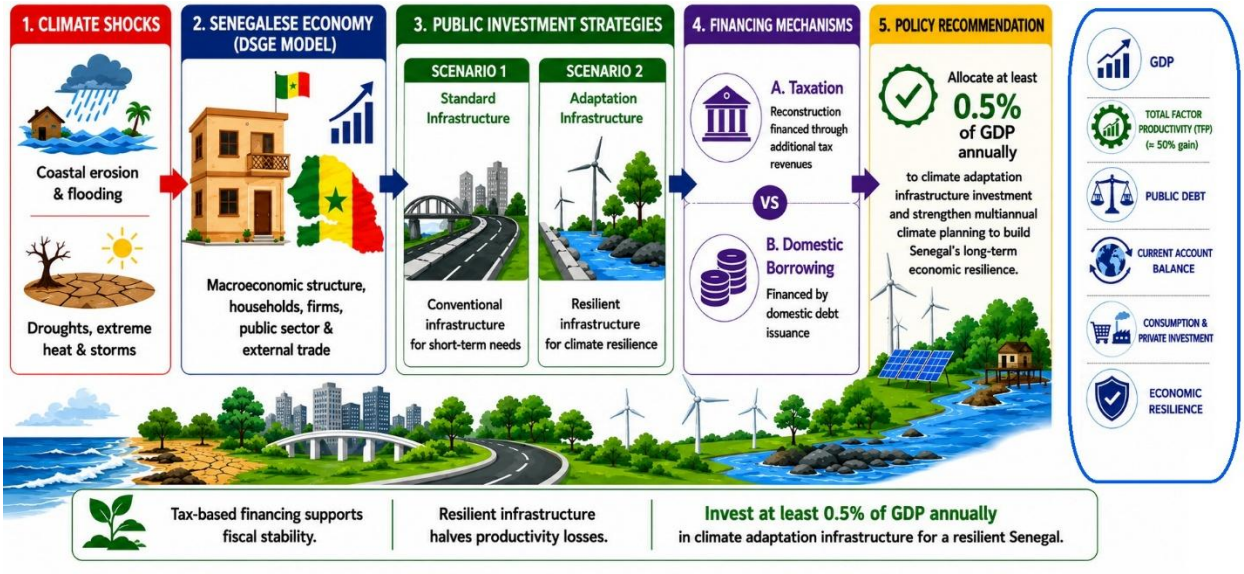
Graphical abstract

Senegal is a coastal country in sub-Saharan Africa that is increasingly exposed to coastal erosion and seasonal flooding. This study analyses the macroeconomic effects of a major climate shock using a dynamic stochastic general equilibrium (DSGE) model, with particular attention to post-disaster financing mechanisms and public investment choices. The findings show that tax-based reconstruction financing supports fiscal stability more effectively than domestic borrowing, while resilient infrastructure substantially reduces productivity losses and reconstruction costs. These results suggest that allocating at least 0.5% of GDP to climate adaptation investment could strengthen the country's long-term resilience to climate change.


1. CLIMATE SHOCKS
Coastal erosion & flooding
Droughts, extreme heat & storms
2. SENEGALESE ECONOMY (DSGE MODEL)
Macroeconomic structure, households, firms, public sector & external trade
3. PUBLIC INVESTMENT STRATEGIES
SCENARIO 1
Standard Infrastructure
Conventional infrastructure for short-term needs
SCENARIO 2
Adaptation Infrastructure
Resilient infrastructure for climate resilience
4. FINANCING MECHANISMS
A. Taxation
Reconstruction financed through additional tax revenues
VS
B. Domestic Borrowing
Financed by domestic debt issuance
5. POLICY RECOMMENDATION
Allocate at least 0.5% of GDP annually
to climate adaptation infrastructure investment and strengthen multiannual climate planning to build Senegal's long-term economic resilience.
GDP
TOTAL FACTOR PRODUCTIVITY (TFP) (= 50% gain)
PUBLIC DEBT
CURRENT ACCOUNT BALANCE
CONSUMPTION & PRIVATE INVESTMENT
ECONOMIC RESILIENCE
Tax-based financing supports fiscal stability.
Resilient infrastructure halves productivity losses.
Invest at least 0.5% of GDP annually
in climate adaptation infrastructure for a resilient Senegal.

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Abstract: Senegal is a coastal country in sub-Saharan Africa exposed to coastal erosion and the increasing recurrence of seasonal flooding. Through the Senegal 2050 vision, the country is pursuing a structural transformation of its economy supported largely by endogenous funding mechanisms aimed at achieving sustainable and stable development. This study analyses the economic impact of a major climate shock on the Senegalese economy using a dynamic stochastic general equilibrium (DSGE) model. Two dimensions are examined: (i) the financing mechanisms for post-disaster reconstruction (through taxation or domestic borrowing) and (ii) the nature of public investment (standard infrastructure or resilient infrastructure). The findings show that tax-based financing for post-disaster reconstruction leads to a temporary contraction in consumption and private investment, yet helps limit the deterioration of the current account balance and accelerates the return to fiscal equilibrium. By contrast, reliance on domestic borrowing increases domestic debt over the long term. At the same time, the simulations indicate that preventive investment in adaptation infrastructure reduces total factor productivity (TFP) losses by half and alleviates the fiscal pressure required for reconstruction, reflecting stronger macroeconomic resilience. These findings suggest that the State could incorporate 0.5% of GDP as a minimum budgetary allocation within public investment expenditure and strengthen multiannual climate adaptation planning in order to reinforce resilience to climate change.

Keywords: *DSGE model, Climate change, Adaptation infrastructure, Economic resilience.*

I. Introduction

Climate shocks generate significant impacts on the economic and social trajectory of developing countries. In sub-Saharan Africa, and particularly in Senegal, exposure to climate hazards such as droughts, floods and coastal erosion creates strong structural vulnerability linked to dependence on the agricultural sector, rapid urbanization and insufficient adapted infrastructure [1]. According to World Bank estimates, the lack of adaptation measures could lead to annual economic losses representing 3% to 4% of Senegal's GDP by 2030 and up to 9.4% by 2050, with more than two million additional people potentially falling into poverty [1].

Growing coastal erosion and recent flooding events have further highlighted the climate threat facing Senegal. According to the 2025 Green Budget Report, rising sea levels are intensifying coastal erosion and generating socio-economic and environmental losses along the coastline, where cities whose economic activities account for 68% of GDP are located [2]. Another government report on the 2025 Fiscal Risk Statement identifies a major potential impact of flooding: "Overall, losses are estimated at 38 billion FCFA in the agricultural sector, 856 million FCFA in the livestock sector and 1.2 billion FCFA in infrastructure" [3].

In 2024, Senegal experienced some of the most severe floods of the past fifty years, affecting more than 55,000 people, destroying thousands of hectares of crops and causing forced population displacement [4]. Along the coastline, Saint-Louis city is experiencing accelerated erosion and sea-level rise that directly threaten thousands of households [2]. In Dakar, the capital of Senegal, 36% of the 133.69 km coastline is classified as being at high risk of marine submersion and coastal erosion, 29% at moderate risk and 35% at low risk [5].

These natural disasters contribute to the destruction of public and private capital, temporary productivity losses and increasing fiscal pressure on the State, as governments are required to finance emergency relief, rehabilitation and reconstruction efforts [6]. In Senegal, fiscal responses remain largely reactive. The country regularly allocates between 1% and 3% of its public expenditure to disaster management through emergency interventions or budgetary provisions [7,8]. These expenditures nevertheless place significant pressure on the sustainability of public finances and reduce the government's capacity to undertake long term investments in a context where fiscal space is already constrained. At the same time, the increasing frequency of floods has raised concerns about the effectiveness of the State's response to climate-related shocks.

Since 1994, Senegal has been actively engaged in addressing climate change through its commitment under the United Nations Framework Convention on Climate Change (UNFCCC) [9]. The country has further demonstrated its commitment by adhering to various international and regional agreements, including the 2015 Paris Agreement on greenhouse gases [10], the Dakar Declaration on Climate Change, adopted in Dakar in2023, the African Renewable Energy Initiative (AREI) and the Great Green Wall Programme [11]. Through the adoption of the Senegal 2050 Vision, the country has identified climate resilience, the sustainable management of natural resources and the energy transition as key pillars of its structural economic transformation [11]. In response to multiple economic, fiscal and financial challenges, the State introduced an Economic and Social Recovery Plan (PRES) in 2025 aimed at restoring macroeconomic balances through the prioritized mobilization of domestic resources and reduced reliance on external borrowing.

In this context, infrastructure investment strategy assumes major importance. The trade-off between standard infrastructure, which can be deployed more rapidly yet remains vulnerable to hazards, and adaptation infrastructure, which is costlier yet resilient, complicates public policy. Natural disasters have lasting effects on growth and debt sustainability in vulnerable countries [12,13], whereas investment in resilient infrastructure significantly reduces capital losses and improves post-shock economic recovery [6]. Nevertheless, in West Africa, and particularly in Senegal, few studies have examined investment strategies in resilient infrastructure. Existing work generally evaluates the economic impact of natural disasters through conventional econometric approaches based on panel models [14]. Local case studies or sectoral analyses [12,15], nevertheless, proposed a DSGE (Dynamic Stochastic General Equilibrium) macroeconomic modelling framework adaptable to West African economies and capable of analysing the differentiated role of standard infrastructure and adaptation infrastructure in economic resilience.

From this standpoint, our work seeks to address the following question: to what extent does an investment policy oriented towards climate adaptation improve Senegal's economic and social resilience to climate shocks compared with a strategy centred on standard infrastructure? To this end, we employ the approach developed by Marto *et al.* [12], calibrated to the Senegalese economy and taking into account the vision and institutional constraints of the PRES. Within a forward-looking framework, we assume that the government may choose to invest either in standard infrastructure or in adaptation infrastructure. Then, we assume that a large-scale climate shock occurs in 2030 and analyse its economic impact according to the investment choices made and two

post-disaster reconstruction financing mechanisms: The State may decide to finance reconstruction either through fiscal policy or through borrowing. This approach demonstrates that investment in adaptation infrastructure cushions climate shocks and significantly supports economic recovery following a shock. Nevertheless, after a shock, reliance on fiscal policy for reconstruction may prove ineffective, since the increase in taxation required to mobilize sufficient reconstruction resources may reduce consumption levels and, consequently, public revenues.

II. Literature Review

Definition of the Concepts of Standard Infrastructure and Adaptation Infrastructure

Existing literature demonstrates that investment in resilient infrastructure generates lasting economic and social benefits, particularly through reducing disaster-related losses and strengthening public debt sustainability [6,12]. The distinction from standard infrastructure lies essentially in the integration of the climatic features of the areas within which the infrastructure is intended to operate.

a. Standard Infrastructure

Standard infrastructure refers to facilities and equipment designed according to conventional technical standards, often based on past climatic conditions and the optimization of initial investment costs. Such infrastructure addresses immediate socio-economic needs (roads, sanitation networks, public buildings), yet its vulnerability to extreme climate events leads to frequent capital losses and recurring repair and reconstruction costs. In exposed contexts, its effective lifespan may be significantly shorter than its intended design life [6].

b. Adaptation Infrastructure

Adaptation or climate-resilient infrastructure explicitly incorporates climate projections and extreme risks into its design, materials, location and performance standards. Its purpose is to reduce the structural vulnerability of economies and protect populations against disasters. Examples include dykes and drainage canals designed for extreme rainfall events, elevated roads in flood-prone areas, coastal protection structures against erosion and marine submersion, and public buildings resistant to cyclonic winds. Initial investment costs are generally higher, yet their

net socio-economic return is greater over the long term, since they reduce capital losses, ensure continuity of essential public services and facilitate post-disaster economic recovery [12].

Infrastructure and Economic Growth

Economic theory highlights investment in public infrastructure as a fundamental pillar of development. For Smith [16], infrastructure appears as an essential public good for the expansion of markets, whereas Marxist theory, notably through Marx and Engels [17], defines it as the material foundation of every mode of production. Keynes [18] highlighted its countercyclical role by legitimizing public works as instruments of economic recovery and macroeconomic stabilization. With endogenous growth theory from e.g., Barro [19], infrastructure became integrated into productive capital, enabling higher productivity, the promotion of economies of scale and the reduction of regional disparities.

Empirical studies confirm this importance. Javid *et al*. [20] show that infrastructure stimulates growth and strengthens household resilience, whereas Blimpo *et al*. [21] and Dorosh *et al.* [22] emphasize its role in food security and the integration of rural markets. Nevertheless, certain studies [23,24] point out that the effects may differ according to the type of infrastructure and its management, particularly in sub-Saharan Africa. Overall, the literature converges on the view that infrastructure, through reducing transaction costs, stimulating private investment and improving well-being, constitutes a central driver of inclusive growth and structural transformation.

Natural Disasters and the Challenges of Economic Resilience

Depending on their magnitude, climate shocks may cause the destruction of an economy's assets (direct effects), including housing, businesses, productive capital, infrastructure, crops and livestock [25]. Such damage frequently leads to major short- and long-term changes in post-disaster economic activity (indirect effects), particularly through short- and long-term economic losses affecting both production and consumption, as well as the associated economic recovery trajectories. The impact of these phenomena may be understood differently at the household and business levels and, more broadly, at the macroeconomic level.

Beyond material and human losses, the damage caused by these disasters directly affects household well-being and economic resilience. Anttila-Hughes and Hsiang [26] showed that an

average typhoon in the Philippines reduces annual household net income (among both rich and poor households) by 6.6% in the short term and structurally alters the economic trajectory of the most vulnerable households, trapping them in persistent poverty. More broadly, several studies have shown that shocks reduce the capacity of households to invest, accumulate capital and, above all, escape poverty [27,28]. They also reduce children's access to education [29], as well as access to adequate food and quality healthcare [30].

Businesses located in disaster-affected areas generally experience productivity and employment losses [31], which may lead to bankruptcies, particularly among small and medium-sized enterprises [32]. The uncertainty generated by disasters also restrains investment levels among these firms, including beyond the directly affected areas [33]. Nevertheless, businesses may also benefit from the positive effects associated with post-disaster reconstruction efforts. This is reflected in a tendency towards increased assets and employment, generating positive effects [31,34], even though the recovery of small businesses remains strongly dependent on access to credit and government support [35].

At the aggregate level, natural disasters translate into productivity and capital shocks that weigh on growth. Lazzaroni and Bergeijk [36] and Klomp and Valckx [37] highlighted a significant negative effect of disasters on GDP per capita, particularly pronounced in developing countries and in the case of hydrometeorological hazards. Indirect losses generally appear more persistent [38] and may significantly reduce growth over several years [39].

Measuring Economic Impacts and Policy Simulation

From a methodological standpoint, the assessment of direct losses is generally conducted using catastrophe models and empirical data analyses based on actual observed damage [25]. Studies focusing solely on immediate impacts nevertheless substantially underestimate the total cost of disasters [38,39]. Econometric and simulation models provide a more comprehensive understanding of the dynamics of economic variables in relation to disasters and help identify the transmission channels of resilience policies.

Econometric and microeconomic approaches, particularly methods based on panel data, have highlighted the statistical relationships between the frequency or intensity of disasters and

economic growth [39,40]. By combining micro-level data (household surveys) with physical measurements of cyclone intensity and an instrumental variable panel model, Anttila-Hughes and Hsiang [26] show that cyclones in the Philippines generate persistent income losses for households. Leiter, Oberhofer and Raschky [34], using accounting data and fixed-effects panel models, highlight the disruptions caused by floods to European firms despite reconstruction efforts. These approaches nevertheless remain largely correlational and struggle to identify transmission mechanisms. They do not allow simulation of the economy as a whole, nor do they make it possible to assess dynamic trajectories and public policy trade-offs.

Recent studies using DSGE models have shown that investment in resilient infrastructure helps mitigate losses associated with natural disasters [12,41], despite high initial costs [42]. These contributions demonstrate that, within a macroeconomic policy framework, DSGE models offer advantages over conventional econometric approaches. In particular, they make it possible to simulate the dynamics of shocks and policies, analyse intertemporal trade-offs and assess in an integrated manner the impacts on production, consumption, investment and fiscal sustainability.

III. Methodology

We use a DSGE model inspired by the work of Marto *et al* [12]. More broadly, DSGE models are macroeconomic modelling frameworks that describe interactions over time between different economic agents (households, firms and public authorities), taking into account expectations and exogenous shocks. They also make it possible to identify the transmission channels of economic policy effects, although they remain complex to calibrate and implement. The approach developed by Marto *et al.* [12] provides a predefined and operational framework for simulating investment policies in resilient infrastructure within the context of sub-Saharan African countries.

Data Sources and Study Variables

The model parameters are calibrated using national data sources such as the Directorate for Forecasting and Economic Studies (DPEE) and the National Agency for Statistics and Demography (ANSD), alongside international sources including the International Monetary Fund (IMF) and the World Bank. These data are supplemented with information drawn from the literature in order to calibrate variables such as public capital returns, whose values are not always

available at the national level but are documented in studies relating to sub-Saharan African countries.

Presentation of the Model

a. General Framework

Marto *et al.* [12] developed a modelling framework specifically designed for small open economies. Their model was calibrated to the case of Vanuatu in order to analyse the macroeconomic impact of a major natural disaster. In the present study, this framework is adapted to the Senegal context in order, first, to represent the transmission channels through which climate shocks (such as recurrent urban flooding and flooding of the Senegal River) affect the real economy and public finances. It is then used to assess the effects of different response strategies, whether preventive or reactive. For the mathematical details and complete formalization, readers may refer to the original article. In this work, we focus on the overall structure of the model, the modelling approach applied to the shock and the simulation of investment scenarios.

b. Structure of the Model

The model encompasses firms operating in two production sectors, as well as households and the government.

❖ **Two Production Sectors**

The model distinguishes between two production sectors. The first relates to tradable goods such as tourism and export agriculture. The second concerns non-tradable goods such as public services and construction. Each sector is based on a Cobb-Douglas function combining three factors: public capital, private capital and labour. Public capital includes both standard infrastructure (roads, ports, schools) and resilient adaptation infrastructure, incorporated within a CES (Constant Elasticity of Substitution) function. The CES production function makes it possible to combine factors (for example standard capital and adaptation capital) by assuming constant elasticity of substitution between them. This allows flexible representation of the substitutability or complementarity of these factors. The model also incorporates total factor productivity (TFP). TFP is influenced by exogenous shocks: in the event of shocks or disasters affecting workers or infrastructure, TFP may experience a temporary decline independently of the quantity of capital or labour available.

❖ **Households and Government**

On the demand side, households are divided into two categories. Ricardian households optimize their consumption intertemporally and have full access to financial markets, whereas liquidity-constrained households consume their entire income in each period and are directly affected by any variation in income or taxation.

The government also plays a central role. It invests in both standard infrastructure and adaptation infrastructure. To this end, it finances its expenditure through taxation, domestic borrowing, external borrowing and a contingency fund. It may also receive external grants, although its investment efficiency is temporarily reduced following a disaster as a result of administrative losses, additional costs and governance-related difficulties.

c. Modelling the Impact of Natural Disasters

The disaster affects the economy through five main channels: permanent destruction of public and private capital, a temporary decline in productivity (unavailable workers and unusable infrastructure), reduced efficiency of public investment during reconstruction, and finally deterioration in solvency leading to higher costs of external commercial borrowing. These channels are calibrated on the basis of the Post-Disaster Needs Assessment conducted for Vanuatu, which estimated losses and damage at approximately 60.8% of GDP. In the present study, we consider a disaster affecting 3% of GDP, in line with World Bank [1] estimates for the 2030 horizon.

d. Calibration of the Model

To calibrate the model, we used data drawn both from the existing literature and from recent Senegalese economic statistics. This stage is important and may require compromises regarding the values of certain parameters in order to estimate the model. The objective is to assign plausible values to the structural parameters and initial endogenous variables so as to reproduce the main characteristics of the country's economy, which is exposed to climate shocks. In accordance with common practice in studies applied to sub-Saharan African economies [12,42,43], some parameters are drawn from the literature, whereas others are directly estimated from national and

international sources. Parameters related to public infrastructure are presented in Table 1 whereas the remaining macroeconomic parameters are reported in Table 2.

❖ Parameters Related to Public Infrastructure

These parameters are summarized in Table 1.

Table 1. Parameters Related to Public Infrastructure

Parameter	Value	Reference
Public infrastructure investment-to-GDP ratio (% of GDP)	8.2%	[1,43,44]
Adaptation investment-to-GDP ratio (% of GDP)	0.34%	[3]
Depreciation rate of standard infrastructure (% per year)	7.5%	[12,13]
Depreciation rate of adaptation infrastructure (% per year)	3%	[12]
Initial return on standard infrastructure investment (%)	25%	[1,8,27,43]
Initial return on adaptation infrastructure investment (%)	30%	[13,45,46]
Infrastructure user fees (% of recurrent costs)	5%	[12,43]
Public investment efficiency (%)	50%	[43,47]
Relative cost of adaptation infrastructure (ratio)	1.25	[41,42]
Damage mitigation capacity of adaptation infrastructure (% of losses avoided)	≈ 33%	[48]

The public infrastructure investment-to-GDP ratio is set at 8.2%, in line with recent estimates from the World Bank [1]. This value is consistent with the approach adopted by Buffie *et al.* [43], who retain an initial investment level of 6% of GDP, which remains close to the observed average of 6.09% for low-income countries in sub-Saharan Africa [44]. For adaptation infrastructure, public expenditure is more modest, representing 0.34% of GDP according to the 2025 Green Budget of the Senegalese Ministry of Finance.

Depreciation rates are differentiated according to the nature of public capital: 7.5% for standard infrastructure, in line with the median observed in developing economies, and 3% for adaptation infrastructure, reflecting their greater durability [12,13,46]. The initial return on investment is set at 25% for standard infrastructure and 30% for adaptation infrastructure, in accordance with estimates from the World Bank [1] and the IMF [46].

User fees for infrastructure services are assumed to cover 5% of recurrent costs, following Buffie *et al.* [43] and Marto *et al.* [12], whereas public investment efficiency is calibrated at 50%, corresponding to the median value for sub-Saharan Africa [47].

Finally, a damage mitigation parameter is introduced in order to measure the capacity of adaptation capital to reduce losses associated with natural disasters. Consistent with Bresch [48], it is assumed that a stock of adaptation infrastructure equivalent to 5% of GDP reduces total damage by approximately one third. The relative cost of adaptation is set at 1.25 times that of standard infrastructure, in accordance with Fernandez-Corugedo *et al.* [41] and Cantelmo *et al.* [42].

❖ Macroeconomic and Structural Parameters

Table 2 below summarizes these parameters.

Table 2. Other macroeconomic and structural parameters

Parameter	Value	Source/ Reference
Trend growth rate (% per year)	6.5	Authors' assumption
Natural resource revenues (% of GDP)	4.4	[49]
Imports-to-GDP ratio (% of GDP)	37	[46,50]
Liquidity-constrained households (% of households)	60	[43]
Share of non-tradable inputs (public capital) (%)	50	[12,43]
Share of non-tradable inputs (private capital) (%)	50	[43]
Value added of the non-tradable sector (% of GDP)	48	[12]
Capital share – tradable sector (%)	40	[43]
Capital share – non-tradable sector (%)	55	[43,51]
Depreciation rate of private capital (% per year)	5	[43]
Real external interest rate (risk-free) (%)	4	[43]
Real domestic interest rate (%)	5	Authors' assumption
Real external commercial interest rate (%)	6	[43,46]
Domestic public debt (% of GDP)	17.5	[52]
Concessional external debt (% of GDP)	49	[52]
Commercial external debt (% of GDP)	28	[52]
Remittances (% of GDP)	9.2	[53]
External grants (% of GDP)	0.23	[53]
Consumption tax rate (%)	18	[3]
Income tax rate (%)	43	[54]

Source: Study Data / Authors' Estimates.

The trend growth rate is set at 6.5%, slightly above the regional average observed in sub-Saharan Africa. Revenues derived from natural resources represent 4.4% of GDP (World Bank, 2021), whereas the imports-to-GDP ratio stands at 37% [50].

In accordance with Buffie *et al.* [43], approximately 60% of households are considered constrained by liquidity restrictions, and the share of non-tradable inputs in the production of public and private capital is fixed at 50%. The value added of the non-tradable sector is estimated at 48%, according to Marto *et al.* [12]. The share of capital in value added is 40% for tradable goods and 55% for non-tradable goods, in line with the medians derived from the GTAP database [43].

Private capital depreciation rates are set at 5%, whereas real interest rates are calibrated at 4% for concessional external debt, 5% for domestic debt and 6% for external commercial debt. Public debt ratios (domestic, concessional and commercial) represent 17.5%, 49% and 28% of GDP respectively [54].

Finally, tax rates on consumption and income are fixed at 18% and 40% respectively, in accordance with the prevailing tax scales. Fiscal adjustment instruments make it possible to assess the government's response to shocks under different financing scenarios (tax increases, debt or transfers).

e. Assumptions and Simulated Scenarios

The model enables the simulation of two types of public policy scenarios. First, reactive scenarios are considered, with the objective of exploring different post-disaster reconstruction financing strategies (through tax increases, borrowing or external assistance). Second, preventive scenarios are examined in order to assess an investment plan in resilient infrastructure, the establishment of a contingency fund, or a combination of both.

❖ Assumption Relating to the Climate Shock

In 2024, the World Bank estimated that, in the absence of adaptation measures, climate shocks could generate annual economic losses representing 3% to 4% of Senegal's GDP by 2030 [1]. Within this framework, we assume that a large-scale shock occurs in 2030, causing damage equivalent to 3% of GDP. We also assume that the shock affects both the tradable goods sector and the non-tradable goods sector equally. In addition, we assume that the government

immediately initiates the reconstruction process following the disaster and aims to restore infrastructure within three years. The end of the reconstruction period is therefore set in 2032 [1].

❖ **Investment Scenarios**

We simulate the following two scenarios:

1. Baseline Scenario: the government invests in standard infrastructure equivalent to 0.5% of GDP each year over a five-year period beginning in 2025, financed through grants and concessional borrowing.

2. Adaptation Scenario: the government invests 0.5% of GDP per year in resilient infrastructure, likewise financed through grants and concessional borrowing.

IV. Results

The analysis is conducted in two main phases. In the first phase, we assume that the State maintains its initial investment strategy focused exclusively on standard infrastructure but adopts a "reactive approach" consisting of mobilizing funds for post-disaster reconstruction. We therefore analyse the financing mechanisms (through taxation or domestic borrowing) and their effects on economic recovery. In the second phase, we assume that the State chooses to invest proactively in the construction of resilient infrastructure, after which we analyse the impact of the disaster in comparison with the baseline scenario.

Analysis of the Economic Impact of Post-Disaster Reconstruction Financing Mechanisms in the Baseline Scenario

a. Simulation of Tax Rates for Reconstruction

In order to mobilize the resources required for reconstruction, we consider two possible cases in which the government may either increase consumption tax (VAT) and income tax or resort to domestic borrowing. These two mechanisms enable the State to avoid further expansion of external debt. The figure below illustrates the extent to which the government must adjust consumption tax and income tax in order to mobilize the funds required for reconstruction over a three-year period following the disaster.

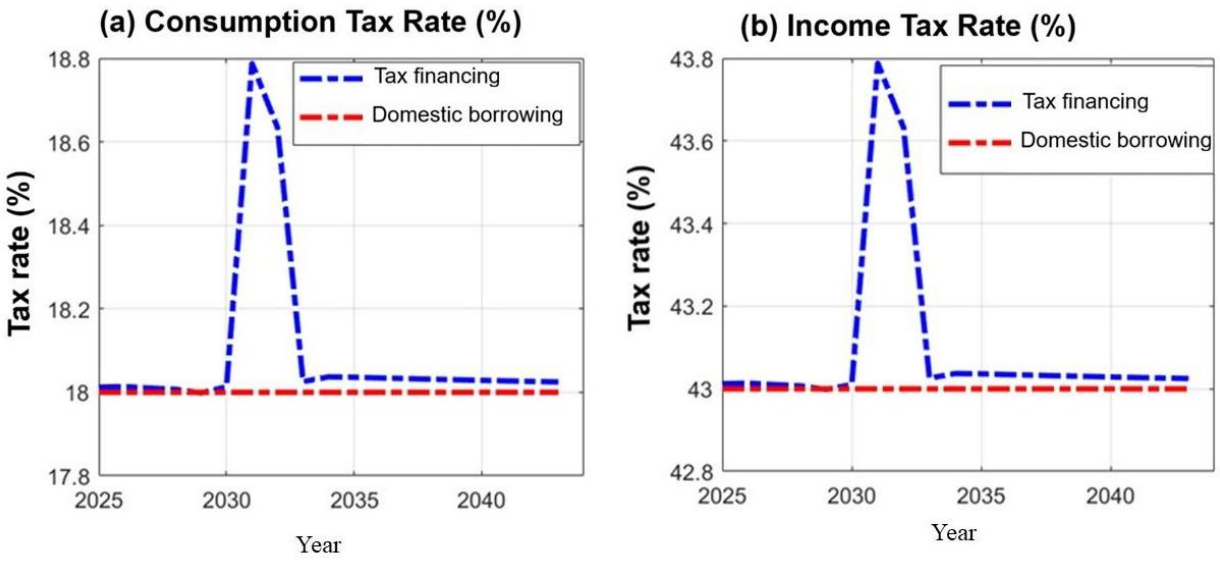


Figure 1. Simulated Tax Rate Adjustments under Alternative Post-Disaster Reconstruction Financing Strategies. ***Source:*** Authors' calculations based on the calibrated DSGE model.

The left-hand panel of Figure 1 shows that, in order to finance reconstruction, the government must initially increase the consumption tax rate from 18% to approximately 18.8% in 2031, representing an increase of 0.8 percentage points. From the second year of reconstruction onwards, the government may apply a rate of 18.61%, followed by a rate of 18.01% in the third year, corresponding approximately to a return to the initial level. By contrast, reliance on borrowing does not appear to exert any effect on fiscal instruments.

The right-hand panel of Figure 1 shows that the income tax rate must increase from 43% to 43.8% in the short term, also representing an increase of 0.8 percentage points. At the end of the third reconstruction year, this fiscal pressure gradually declines and stabilizes around 43.01% in the medium and long term.

b. Impact of Reconstruction Financing Mechanisms on the Current Account Deficit and Domestic Debt

Financing reconstruction through taxation or domestic borrowing generates immediate yet differentiated effects on variables such as the current account deficit and domestic debt (Figure 2).

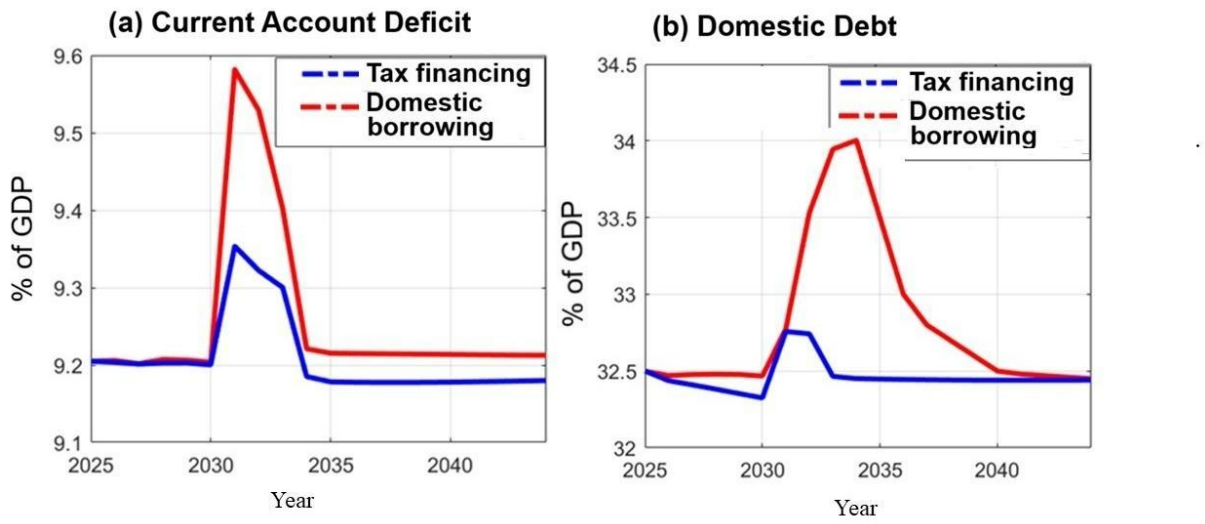


Figure 2. Simulated Impact of Alternative Post-Disaster Reconstruction Financing Mechanisms on the Current Account Deficit and Domestic Debt.

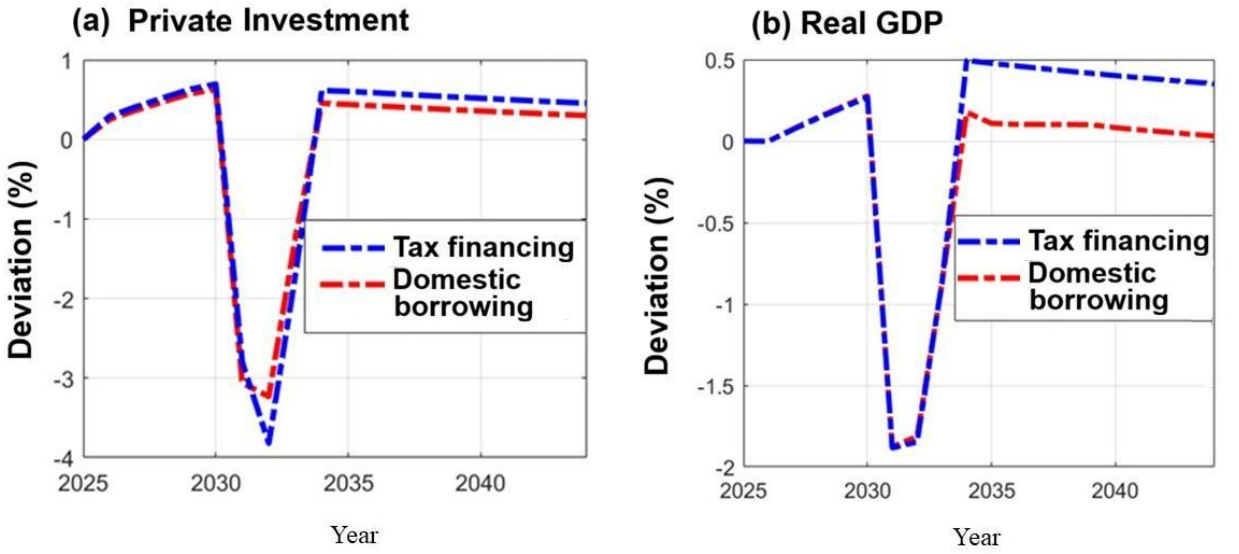
Analysis of Figure 2 shows, in the left-hand panel, that financing through taxation would lead to a more moderate increase in the deficit in the short term compared to borrowing. With a difference of approximately 0.23 percentage points, tax-based financing would help mitigate the deterioration of the current account balance observed during the reconstruction period. This deterioration gradually diminishes from the end of the reconstruction programme onwards, coinciding with the return to the initial tax rates three years after the shock.

Domestic debt (right-hand panel of Figure 2) displays markedly different trajectories depending on the financing mechanism adopted. When reconstruction is financed through taxation, domestic debt increases only slightly, by 0.01% of GDP during the reconstruction phase. By contrast, reliance on domestic borrowing would probably lead to an immediate increase in the overall level of domestic debt, with a rise reaching up to 3.5 percentage points. Under domestic borrowing, it would take nearly a decade after the disaster (by about 2040) before domestic debt had returned to its initial level.

c. Macroeconomic Impact of Reconstruction Financing Mechanisms

Figure 3 below summarizes the impact of reconstruction financing mechanisms on income, consumption, investment and GDP.

Figure 3. Impact of Reconstruction Financing Mechanisms on Income, Consumption, Investment and GDP.



Source: Study Data / Authors' Estimates

Figure 3. Simulated Effects of Alternative Post-Disaster Reconstruction Financing Mechanisms on Key Macroeconomic Variables: (a) Private Investment, (b) Real GDP, (c) Real Wages and (d) Private Consumption.

Although the effects of the financing mechanisms on real GDP and real wages are not entirely comparable, tax increases remain more harmful to households than reliance on debt, albeit with a recovery accompanied by moderate real GDP growth during the post-disaster period.

Under the option of financing the reconstruction programme through the mobilization of tax revenues, private investment growth could experience a contraction of approximately 3.9 percentage points relative to its initial level at the time of the shock, compared with 3.2 percentage points under domestic borrowing. After the reconstruction phase, tax-based financing nevertheless significantly accelerates the recovery dynamics of private investment in contrast with debt financing.

Similarly, real GDP would decline by more than 1.58 percentage points in the short term. One year after the reconstruction phase, GDP returns to its initial level and subsequently records a positive deviation that gradually diminishes over the remainder of the period. This deviation is more pronounced when the government finances reconstruction through taxation rather than borrowing.

The evolution of real wages is expected to follow a similar trend regardless of the financing mechanism adopted. Following the shock, real wages could decline by 2 percentage points relative to their initial level before experiencing a marked improvement after the reconstruction period, remaining relatively strong throughout the rest of the period.

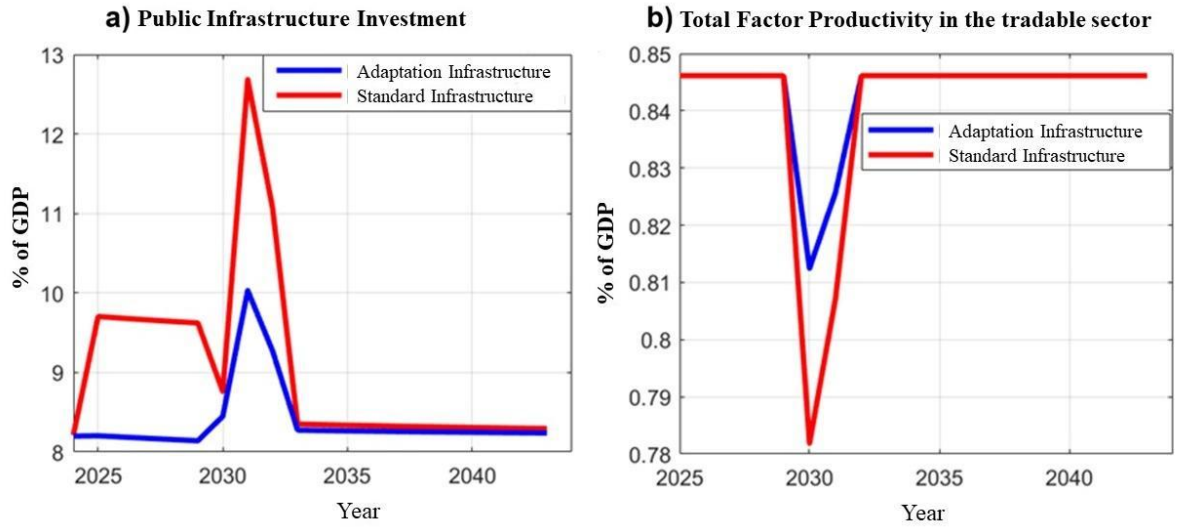
As for private consumption, two effects are observed: when reconstruction is financed through taxation, private consumption could decline by 1.58 percentage points, compared to 1.1 percentage points under borrowing, before gradually returning to its initial trend in the post-disaster years.

Comparative Impact of Standard and Adaptation Infrastructure Investments on Economic Resilience to Climate Shocks

At this stage of the analysis, we examine economic resilience to the same shock, this time assuming that the government adopts a preventive policy by constructing resilient infrastructure during the five years preceding the disaster (2025–2029). Under this scenario, the government allocates 0.5% of GDP per year to the development of infrastructure adapted to climate change, in addition to recurrent investment in standard infrastructure, estimated at 8.2% of GDP in the baseline scenario.

a. Impact on the Investment Ratio and TFP

Figure 4 below shows the evolution of the public infrastructure investment ratio as a percentage of GDP and total factor productivity (TFP).



Source: Study Data / Authors' Estimates

Figure 4. Evolution of the Public Infrastructure Investment Ratio as a Percentage of GDP

The left-hand panel of Figure 4 shows that, all else being equal, standard capital increases before the shock, whereas adaptation capital remains almost constant. Within the structure of the model, investment in standard infrastructure is endogenous and responds to economic conditions, whereas investment in adaptation infrastructure is determined exogenously (constant share of GDP). This explains the observed evolution. During the reconstruction phase, investment in standard infrastructure could reach 12.7% of GDP, compared to only 10% of GDP for adaptation infrastructure, representing a gain of 2.7 percentage points of GDP.

The right-hand panel of Figure 4 reveals a less pronounced decline in total factor productivity (TFP) when the government directs its resources towards the acquisition of infrastructure adapted to climate change. Conversely, investment in standard infrastructure induces a greater deterioration in TFP, with a decline reaching approximately 0.066 percentage points following the shock, compared with only 0.03 percentage points in the case of resilient infrastructure.

b. Macroeconomic Impact of the Shock According to the Type of Infrastructure

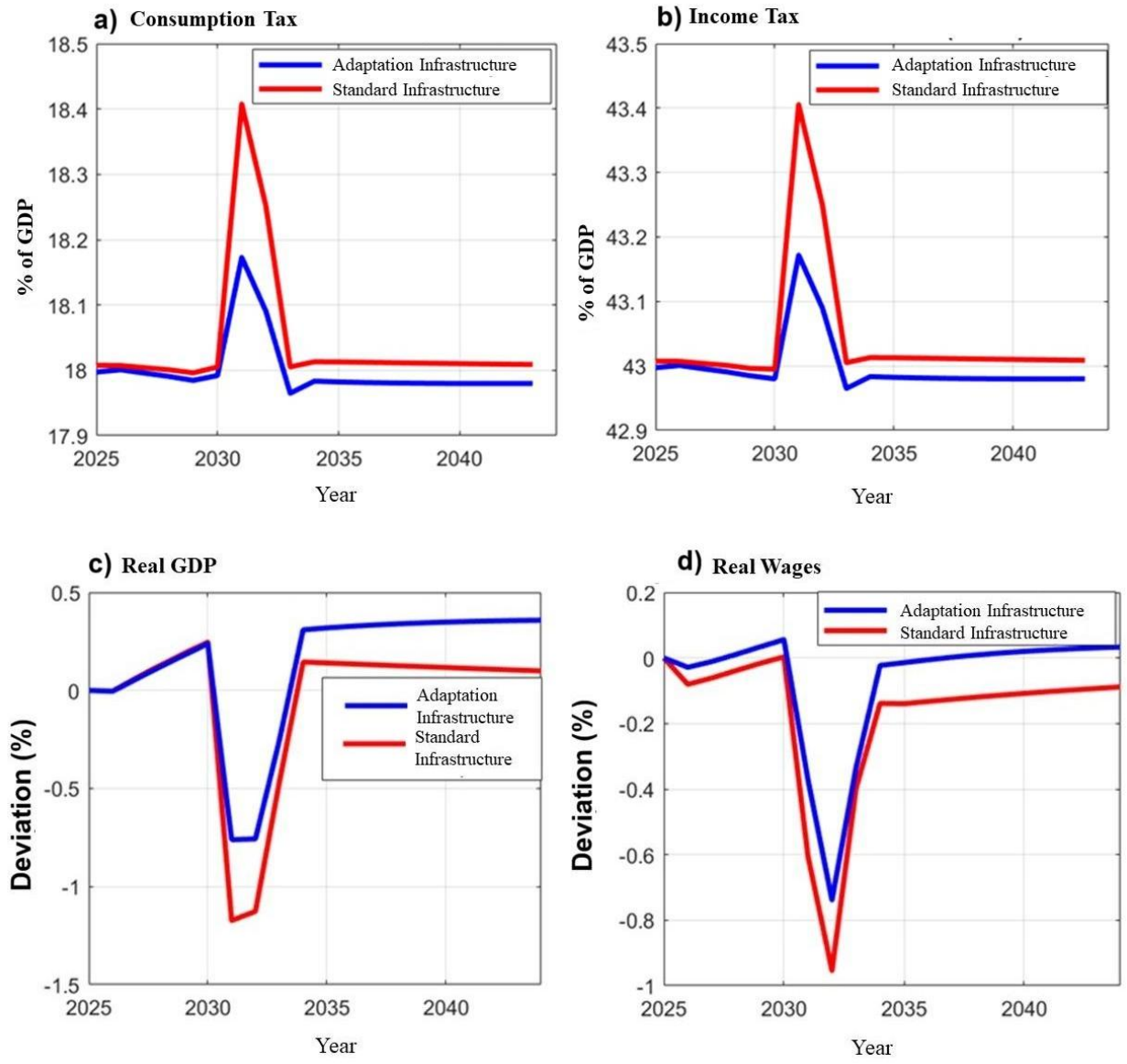
As illustrated in Figure 5 below, if the government invests in adaptation infrastructure, the climate shock could lead to an increase in the consumption tax rate from 18% to 18.19%. By contrast, if resources are devoted to the acquisition of standard infrastructure, the tax rate could reach 18.41% following the shock, representing a difference of 0.22 percentage points.

At the same time, income tax could increase from 43% to 43.19% if investment is directed entirely towards adaptation infrastructure, compared to 43.41% if investment is allocated to standard infrastructure, again representing a difference of 0.22 percentage points. Adaptation infrastructure reduces the potential damage associated with natural disasters, thereby decreasing the financial gap that must be covered for post-disaster reconstruction. Following this phase, tax rates return to their initial levels.

Furthermore, investment in adaptation infrastructure would reduce the decline in real GDP and the growth rate of real wages following the disaster. The post-disaster period nevertheless remains characterized by moderate growth in real GDP, which gradually returns to its initial level if the government invests entirely in standard infrastructure. By contrast, if investment is directed towards resilient infrastructure, real GDP growth tends to stabilize at a level above that observed before the disaster. As regards real wages, they return to their pre-shock level when the government invests in adaptation infrastructure, whereas they stabilize below the pre-shock level when investment is concentrated in standard infrastructure.

V. Discussion

We simulated a climate shock occurring in 2030, with assumed damage equivalent to 3% of GDP. The results highlighted economic dynamics that differ according to the financing mechanism adopted for reconstruction and the type of infrastructure prioritized by the State. This provides a clearer understanding of the trade-offs that Senegal may face between fiscal stability, recovery efficiency and long-term resilience.



Source: Study Data / Authors' Estimates

Figure 5. Evolution of macroeconomic aggregates under the adaptation scenario: (a) consumption tax (% of GDP), (b) income tax (% of GDP), (c) real GDP (deviation, %), and (d) real wages (deviation, %), comparing adaptation infrastructure and standard infrastructure.

Financing Reconstruction: Trade-off Between Economic Efficiency and Fiscal Sustainability

The results show that financing through taxation, although it places immediate pressure on household income and consumption, limits the deterioration of the current account balance and domestic debt more effectively than exclusive reliance on domestic borrowing. This finding is in line with the works of Buffie *et al.* [43] and Marto, Papageorgiou and Klyuev [12], who emphasize that rapid fiscal adjustment, even when temporary, contributes to preserving macroeconomic stability after a disaster. Tax increases nevertheless lead to a contraction in consumption and private investment in the short term, reflecting a crowding-out effect consistent with Keynesian literature.

In the medium term, the recovery of real GDP growth and real wages under the tax-financing mechanism indicates stronger economic resilience, which may be supported by gradual fiscal adjustment and the restoration of private sector confidence. By contrast, although reliance on domestic borrowing cushions the initial shock to consumption, it generates a self-sustaining accumulation of domestic debt whose effects may compromise long-term fiscal sustainability. This suggests that the State should maintain a degree of caution in balancing fiscal adjustment and domestic borrowing in post-disaster management.

Preventive Investment: Adaptation Infrastructure as Shock Absorbers

Analysis of economic resilience in relation to investment choices between standard infrastructure and adaptation infrastructure shows that the latter possesses a greater capacity to mitigate productivity losses and limit post-disaster fiscal pressure. The simulation reveals that preventive investment in resilient infrastructure reduces by half the decline in total factor productivity (TFP) and decreases the need for fiscal adjustment following the shock. These findings support the conclusions of Cantelmo *et al.* [42], that adaptation infrastructure constitutes an investment with delayed returns yet lasting stabilizing effects.

During the reconstruction phase, the standard infrastructure is predominant because it can be immediately mobilized for the rapid restoration of production. This strategy nevertheless remains costly in the long term, since it does not incorporate gains in structural resilience. By contrast, although adaptation infrastructure is more expensive to implement, it improves the trajectory of real GDP and real wages after the disaster, confirming its role as a form of “macroeconomic insurance capital” [12,46].

Implications for Economic Policy

These results suggest that an optimal climate risk management strategy for the State should combine structural prevention (through anticipatory investment in resilient infrastructure) with adaptive fiscal mechanisms (including temporary fiscal adjustment and carefully managed concessional borrowing). Exclusive reliance on a reactive strategy based on ex post reconstruction exposes the economy to greater volatility in GDP and public finances.

In the context of Senegal, where climate vulnerability is intensifying and fiscal space remains constrained, investment in adaptation infrastructure appears not only as a resilience imperative but also as a driver of economic sustainability. These findings underscore the importance of integrating climate considerations into public investment planning , in line with the Senegal 2050 Vision and the PRES.

The objective of this study was to analyse the economic and social impact of a major climate shock on the Senegalese economy using a dynamic stochastic general equilibrium (DSGE) model, through comparing the effects of two public investment strategies: the construction of standard infrastructure and the development of adaptation infrastructure. The results obtained show that both reconstruction financing mechanisms and the nature of infrastructure constitute decisive drivers of economic resilience.

On the one hand, although tax-based financing generates an immediate social cost through temporary tax increases and contraction in private consumption, it enables more rapid stabilization of the current account deficit and domestic debt than financing through domestic borrowing. The latter mitigates the recessionary effect in the short term but may create prolonged dependence on domestic indebtedness and slow recovery in the medium term.

On the other hand, when the State incorporates a preventive investment strategy centred on adaptation infrastructure, the outcome proves economically more efficient over the long term. Resilient infrastructure significantly reduces the loss of total factor productivity (TFP) and post-disaster fiscal pressure, whilst supporting more stable growth in real GDP and real wages. This finding confirms that adaptation infrastructure acts as a structural shock absorber, limiting the magnitude of shocks and facilitating a more rapid return to economic equilibrium.

The lessons drawn from this work suggest that Senegal’s macroeconomic resilience to climate shocks depends upon a combination of structural prevention and fiscal response capacity.

Adaptation infrastructure should therefore not be perceived as an additional cost, but rather as a strategic investment capable of reducing vulnerability and supporting inclusive long-term growth, in line with the Senegal 2050 Vision.

As a recommendation, the State should increase the share of preventive investment allocated to adaptation infrastructure. The annual investment of 0.5% of GDP in resilient infrastructure simulated in this study resulted in a halving of productivity losses associated with the shock. The State could therefore incorporate this proportion as a minimum budgetary threshold within public investment expenditure and strengthen multiannual planning for climate adaptation.

Furthermore, adaptation programmes should target strategic sectors and areas. According to our results, declines in GDP and TFP are more pronounced in sectors exposed to and dependent upon standard infrastructure. It would therefore be relevant to concentrate adaptation investment within these sectors in order to maximize the stabilizing effects observed.

VI. Conclusion and Policy Recommendations

The objective of this study was to examine the economic and social effects of a major climate shock on the Senegalese economy using a Dynamic Stochastic General Equilibrium (DSGE) model. Specifically, the analysis compared the outcomes of two public investment strategies: the construction of conventional infrastructure and the development of climate adaptation infrastructure. The findings indicate that both the financing mechanism for post-disaster reconstruction and the nature of the infrastructure constitute key determinants of economic resilience.

On the one hand, although tax-financed reconstruction entails short-term social costs through temporary tax increases and a contraction in private consumption, it enables a faster stabilization of the current account deficit and domestic public debt than reconstruction financed through domestic borrowing. Although domestic borrowing mitigates the immediate recessionary effects of the shock, it may generate prolonged dependence on domestic debt and delay the recovery over the medium term.

On the other hand, incorporating a preventive investment strategy based on climate-resilient infrastructure proves to be more economically efficient in the long run. Resilient infrastructure

significantly reduces losses in Total Factor Productivity (TFP) and alleviates the post-disaster tax burden, while supporting more stable growth in real GDP and real wages. These findings confirm that adaptation infrastructure acts as a structural buffer, mitigating the severity of climate shocks and facilitating a faster return to macroeconomic equilibrium.

Overall, the results suggest that Senegal's macroeconomic resilience to climate shocks depends on a combination of structural prevention and effective fiscal response capacity. Climate adaptation infrastructure should therefore not be regarded as an additional expenditure but rather as a strategic investment that reduces vulnerability and promotes sustainable and inclusive long-term economic growth, in line with the objectives of the Senegal Vision 2050 development agenda.

From a policy perspective, the government should increase the share of preventive investment allocated to climate adaptation infrastructure. In our simulations, an annual investment equivalent to 0.5% of GDP in resilient infrastructure reduced climate-induced productivity losses by approximately 50%. This investment level could therefore be adopted as a minimum budgetary benchmark for public investment, strengthening medium-term planning for climate adaptation.

Furthermore, adaptation policies should prioritize the most vulnerable regions and strategic economic sectors. Our results show that declines in GDP and TFP are more pronounced in sectors that are highly exposed to climate risks and heavily dependent on conventional infrastructure. Concentrating adaptation investments in these sectors would therefore maximize the stabilizing effects identified in this study and enhance the overall resilience of the Senegalese economy.

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